SPECIFICATIONS

FOR A

HORIZONTAL BACK-ACTING

COMPOUND-SCREW ENGINE

FOR

GUNBOAT No. 2.

OF 870 TONS DISPLACEMENT,

TO BE NAMED THE

THE ENGINE WITH ITS AUXILIARIES OF 1,300 I. H. P.

UNDER FORCED DRAUGHT;

INCLUDING

BOILERS, SCREW-PROPELLER, AND ALL APPENDAGES AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF TOOLS, INSTRUMENTS, AND DUPLICATE PIECES TO BE FURNISHED.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

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U. S. Rev. Cutter Service

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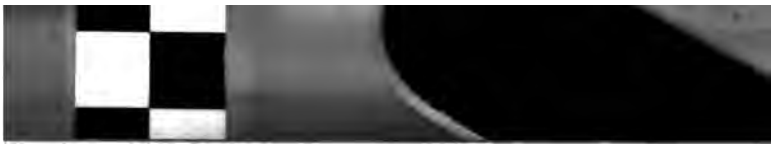
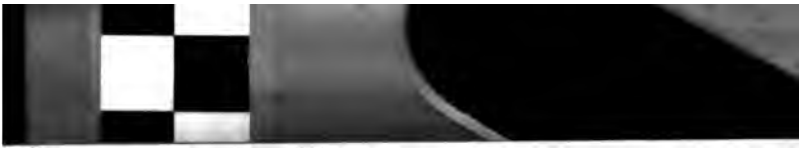




SPECIFICATIONS

FOR A

HORIZONTAL BACK-ACTING

COMPOUND-SCREW ENGINE

AND

BOILERS

FOR

GUNBOAT No. 2,

OF 870 TONS DISPLACEMENT.

REFERENCE BEING HAD TO THE ACCOMPANYING DRAWINGS, FORMING PART OF THESE SPECIFICATIONS.

GENERAL DESCRIPTION.

The engine is to be of the horizontal back-acting type, with a high-pressure cylinder of 25 inches diameter and a low-pressure cylinder of 46 inches diameter, with a stroke of piston of 33 inches. The high-pressure cylinder will be forward of the low-pressure. Both cylinders with their heads and covers will be steam-jacketed. The cylinder-casings will include the valve-chests. The main steam-valves will be of the piston-type, one for the high-pressure and two for the low-pressure cylinders. The valve motion is to be of the radial type shown in the drawings, arranged to cut off steam between the limits of 0.25 and 0.66 of the stroke of pistons. The high-press-

ure piston will have one piston-rod, connected to a cross-tail, which in turn will be connected to the cross-head by two side-rods. The low-pressure piston will have two piston-rods, connected directly to the cross-head. All shafts will be of steel. The crank-shaft will be in one forging with cranks at right-angles. It will rest in three bearings in pillow-blocks contained in a single casting. The propeller will be three-bladed, of manganese bronze. The condenser will be cylindrical, with tubes running fore-and-aft, the water passing through the tubes. The condenser will be built up of brass and composition. It will have a cooling surface of about 2,466 square feet. The circulating-pump will be of the centrifugal type, driven by its own engine, and will be arranged to free the bilges of water in case of necessity. The air-pump will be inclined and double-acting, worked by a crank on forward end of crank-shaft. There will be in the fire-room two vertical duplex pumps for feeding the boilers; one to be used as a feed-pump only, and the other one also as an auxiliary fire, bilge, and distiller-pump. There will be two cylindrical horizontal fire-tube boilers, with tubes back of furnaces, to carry a working pressure of 100 pounds by gauge; each boiler to be about 18 feet 4½ inches long and 8 feet 8 inches diameter. The boilers will have a total grate surface of 93 square feet and a heating surface of 2,796 square feet. There will be one fixed smoke-pipe, about 41 feet 6 inches high above the grates.

The fire-room, running athwartships, will be arranged to work under air-pressure when required. There will be two blowers, capable of supplying each 10,000 cubic feet of air per minute under a pressure of 4 inches of water. There will be an auxiliary pump for bilge and fire use. There will be an auxiliary condenser into which all auxiliary machinery can exhaust. There will be steam reversing-gear, distilling apparatus, a steam ash-hoist, a steam windlass and capstan, and such other auxiliary or supplementary machinery, tools, instruments or apparatus as may be described in the following detailed specifications or shown in the official drawings.

CYLINDER-CASINGS.

The cylinder-casings, which will include the steam and exhaust-ports and passages, inboard heads and valve-chests, are to be of cast-iron. The casing for high-pressure cylinder is to be 30 inches diameter inside and 1 inch thick; that for the low-pressure cylinder is to be 51 inches diameter and 1 inch thick. They will be fitted with cylinder linings which will inclose an annular space of $1\frac{1}{2}$ inches.

The cylinder-heads are to be made with double shells $\frac{7}{8}$ inch thick, amply stiffened by ribs of same thickness. They will have suitable openings cored in for the stuffing-boxes and accurately bored to receive them. A man-hole will be made in the low-pressure head, which is to be bored and faced to receive the cover.

The cylinder-casings will rest upon legs, with sole-plates, well ribbed, cast on them, of the same length as the casings, $11\frac{1}{2}$ inches and 8 inches wide, and faced $1\frac{1}{2}$ inches thick. The distance from axes of cylinders to faces of sole-plates will be 30 inches.

CYLINDER-LININGS.

The linings are to be of close-grained cast-iron, as hard as can be worked. They are to be 1 inch thick, and made with flanges and facings, accurately fitted in and secured in the casings. They are to be smoothly bored in place to their respective diameters of 25 and 46 inches, for a stroke of 33 inches. The linings will be secured in place by bolts passing through the cylinder-heads, with nuts on the outside; the joint at inboard end of each cylinder being made tight by a copper grommet under the flange. A copper wire or grommet, with follower and bolts, will likewise be used for packing the expansion-joint at the outboard end of each cylinder-lining.

CYLINDER-JACKETS.

The steam jacket of each steam cylinder will consist of the space between the cylinder casing and lining, and of the bol-

low head and cover. The ribs of heads and covers will have holes to allow the passage of steam and water. The jacket steam is to be taken from the top or side of the main steam-pipe outside the engine stop-valve. A branch pipe will lead to each separate portion of the jackets. A drain-pipe will lead from the lowest part of each portion of each jacket. All the drains from the jacket spaces of each cylinder will lead to an approved automatic trap with blow-through and bye-pass valves, thence to the feed-tank, with a branch to bilge. All the steam and drain-pipe branches to have stop-valves. There will be an adjustable reducing-valve in the pipe taking steam to the low-pressure jacket.

CYLINDER-COVERS.

The cylinder-covers are to be made of the very best cast-iron, with double shells $\frac{7}{8}$ inch thick, well stiffened by ribs of same thickness. Openings for man-holes to be cored out, bored, and faced. The covers are to be faced true on the inside and rough finished on the outside. They will have faced flanges $1\frac{1}{2}$ inches thick, and be secured in place by wrought-iron bolts $1\frac{3}{8}$ inches diameter with finished nuts. Bolts to be spaced not over $5\frac{1}{2}$ inches apart.

CYLINDER MAN-HOLES AND COVERS.

The cylinder man-holes, one on each cylinder-cover and one on low-pressure cylinder-head, will be 15 inches in diameter, with double-shell covers, finished on the outside. The covers will have faced flanges 3 inches wide and $1\frac{3}{8}$ inches thick, and be secured in place by wrought-iron bolts $1\frac{1}{4}$ inches diameter, spaced not over 6 inches apart.

ENGINE STOP-VALVE.

The engine stop-valve, which will also be used as a throttle-valve, will have its composition seat in the casing of the high-pressure steam-chest, and will have an opening $9\frac{1}{4}$ inches diameter. The hand-wheel will be of wrought-iron at least 26 inches diameter.

RECEIVER.

The receiver will consist of the space between the high-pressure and low-pressure piston-valves, and their connecting pipe.

There will be a 3-inch pipe, with stop-valve, connecting main steam-pipe to receiver; and a spring safety-valve of 2 inches diameter, with nickel seat on the receiver, loaded to 40 pounds per square inch above the atmosphere.

VALVE-CHESTS AND COVERS.

The high and low-pressure valve-chests will have openings at each end for inserting and removing the valves, and will be closed by single plate covers well-ribbed, with faced flanges at least 3 inches wide and $1\frac{1}{4}$ inches thick.

The inboard covers will contain the valve-stem stuffing-boxes, which, together with the glands, will be of composition. The packing spaces will be $\frac{5}{8}$ inch wide and $4\frac{1}{2}$ inches deep, and fitted for either metallic or ordinary packing. Both inboard and outboard covers will have, projecting from their inner surfaces, suitable guides bushed with brass for sustaining the weight of the valves. Suitable bosses will be cast on the upper surfaces of steam-chests, directly over each steam-port, for the attachment of approved oil-cups.

VALVE-CHEST LININGS.

There will be a working lining at each end of each valve-chest. They will be made of cast-steel of the toughest quality combined with a suitable degree of hardness. They are to be $1\frac{1}{4}$ and $1\frac{1}{2}$ inches in thickness, and will be secured as shown in drawing, all joints being made steam-tight; and will be smoothly and accurately bored in place to a diameter of 15 inches for the high-pressure and 16 inches for the low-pressure cylinder.

STEAM-PORTS.

The high-pressure cylinder steam-ports will be 2 inches and the low-pressure $2\frac{1}{2}$ inches wide. There will be 10 diagonal, alternating right and left, bridges in each valve-seat. All bridges are to be $\frac{3}{4}$ inch wide.

MAIN PISTON-VALVES.

The valves of both high and low-pressure cylinders will be made of composition and fitted with cast-iron wearing and packing-rings. The metal in shell of high-pressure valve will be $\frac{5}{16}$ inch and in low-pressure valves $\frac{3}{8}$ inch thick. The central connecting trunk will be not less than 10 inches internal diameter in the high-pressure valve and $10\frac{1}{2}$ inches in the low-pressure valves. Each valve will have bolted to it at either end a central boss, with radial arms, for the attachment of the valves to stems.

MAIN VALVE-STEMS.

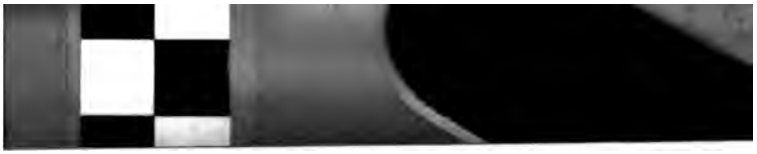
The valve-stems will be made of forged steel 2 inches diameter at their connections with the valves, and increased to $2\frac{3}{4}$ inches in the stuffing-boxes. They will be thoroughly secured to valves, and the nuts retained by a suitable locking device. A prolongation of each valve-stem will carry a sleeve of cast-iron $\frac{3}{8}$ inch thick, which will move in a brass bushing fitted in outboard-valve cover, each bushing being provided with an efficient lubricating device.

MAIN VALVE-STEM CROSS-HEADS.

The main valve-stem cross-heads will be of forged steel, finished all over. Each will be bored to receive its valve-stem, and counter-bored for the recessed valve-stem nuts.

VALVE-GEAR.

The valve-gear is to be of the radial type, and must be so constructed and adjusted as to cut off steam between the limits of $\frac{1}{4}$ and $\frac{3}{5}$ of the stroke of the pistons.



The cut-offs of the high-pressure and low-pressure cylinders are to be capable of being adjusted from the working-platform independently of each other. When cutting off at $\frac{1}{4}$-stroke there must not be a difference of more than $\frac{1}{2}$ inch in the points of cutting off on the inboard and outboard ends of the cylinders; and when cutting off at $\frac{3}{4}$-stroke the difference must not exceed $1\frac{1}{4}$ inches. The angular position of the crank-arm when steam is admitted must be the same in all gears of forward motion. The openings of the exhaust side of the valve when cutting off at $\frac{3}{4}$-stroke must not occur later than 2 inches from the end of the stroke of the high-pressure piston and 1 inch from the end of the stroke of the low-pressure piston; and when cutting off at $\frac{1}{4}$-stroke, must not be earlier than $7\frac{1}{4}$ inches and $3\frac{1}{2}$ inches from the ends of the strokes of the high-pressure and low-pressure pistons respectively. The closing of the exhaust side of the valve at maximum cut-off must not occur later than 4 inches and 6 inches from the ends of the strokes of the high-pressure and low-pressure pistons respectively; and at minimum cut-off must not be earlier than $12\frac{1}{2}$ inches and $16\frac{1}{2}$ inches from the ends of the respective strokes. The width of the port opening for steam admission must be at least $1\frac{3}{4}$ inches at maximum cut-off and $\frac{3}{8}$ inch at minimum cut-off in the high-pressure cylinder, and $2\frac{1}{4}$ inches at maximum cut-off and $\frac{7}{16}$ inch at minimum cut-off in the low-pressure cylinder.

The distribution of steam in backward gear must be such as to permit the engines to be reversed quickly and to run astern at maximum power.

ECCENTRICS.

The eccentrics are to be forged on the shaft and truly turned to an eccentricity of $3\frac{1}{2}$ inches, each eccentric lying at an angular distance of 188° in advance of the crank of the corresponding engine.

ECCENTRIC STRAPS AND LEVERS.

Each eccentric strap is to be in two parts, of cast-steel, with brass bushings securely fitted and truly bored to fit the eccentrics. The two parts to be firmly secured together by two bolts of mild steel with lock-nuts and keepers. The two parts of the straps to be separated by suitable brass chipping-pieces. A prolongation of one part of each eccentric strap will form the eccentric lever and will carry two steel pins; one connecting with the primary radius-bar and the other with the valve connecting-rod.

RADIUS-BARS.

The movement of the valves will be regulated by a modification of the "grasshopper" parallel motion, carried by arms on the reversing rock-shaft; each consisting of a primary and a secondary radius-bar. The primary radius-bar is to engage at one end with the corresponding pin in the eccentric lever and to be guided at the other end by a crank on the end of a steel pin working in a bushing at the end of the shorter reversing-arm. The secondary radius-bar is to be bifurcated, and is to engage at its double end with a steel pin securely bolted at a suitable point of the primary radius-bar. The other end of the secondary radius-bar is to be carried by a pin in the end of the longer reversing-arm. The radius-bars will be of forged steel, with ends as shown, capable of adjustment to preserve a constant distance between centers when taking up lost motion.

REVERSING ROCK-SHAFTS.

The longer and shorter reversing-arms of each valve-gear are to be made in one piece, of cast-steel, of such form and dimensions as to be a practically rigid support for the radius-bars, and will have a steel pin forced in and secured by feather-keys to form rock-shaft journals. There are to be on this arm suitable means for attaching the connections to the reversing-engine and to the clamping-gear.

REVERSING ROCK-SHAFT BEARINGS.

Each reversing rock-shaft is to be carried by two bearings, those for the high-pressure engine on top of the forward crank-shaft pillow-block, and those for the low-pressure engine on top of the after crank-shaft pillow-block. The rock-shaft pillow-blocks are to be of cast-steel, bolted to the crank-shaft pillow-blocks, and to have composition bearings held down by wrought-iron caps and mild-steel bolts.

VALVE-CONNECTING RODS.

The valve-connecting rods, imparting the motions of the eccentric levers to the valve-motion rock-shafts, will be of forged steel with adjustable ends as shown.

VALVE-MOTION ROCK-SHAFTS.

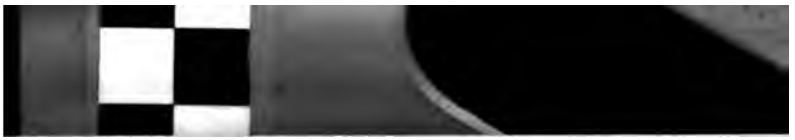
The valve-motion rock-shafts, together with their arms, which are to be shrunk and keyed on, are to be of forged steel, finished all over.

VALVE-MOTION ROCK-SHAFT BEARINGS.

The low-pressure valve-motion rock-shaft will be carried in two adjustable bearings, bolted to the low-pressure cylinder-casing. The bearings for the high-pressure rock-shaft will be carried by a bracket bolted to the high-pressure cylinder-casing, and further supported by a stanchion stepped on the forward engine-frame.

VALVE-LINKS.

The links between the valve-motion rock-shafts and the valve-stem cross-heads will be double, of forged steel, with adjustable conical-ring bearings.



REVERSING-ARM CLAMPING-GEAR.

There will be a clamping device for each reversing-arm, capable of holding it rigidly when the engines are in operation, and of being quickly thrown in and out of gear from the working-platform.

REVERSING-GEAR.

Each engine will have an independent reversing-engine, each consisting of a steam-cylinder and a hydraulic controlling-cylinder with a common piston-rod. These cylinders to be of composition, and to be bolted to the outside engine-frames. The steam-cylinders to be at least 8 inches diameter of bore, and the hydraulic cylinders to be at least 4 inches diameter of bore, with a stroke of about 14 inches. From cross-heads between the steam and hydraulic cylinders bifurcated connecting-rods will lead to bell-cranks carried in bearings on the engine-keelsons. The bell-cranks will be connected by rods with the reversing-arms. The reversing-gear is to be so adjusted that the reversing-arms cannot be thrown over sufficiently far to endanger any part of the mechanism. The steam-pistons to have approved metallic packing, and the hydraulic pistons to have double cup-leathers. Stuffing-boxes to have approved packing. The steam-cylinders to have piston-valves, each giving an opening of not less than $1\frac{1}{2}$ square inches. The hydraulic cylinders to have piston bye-pass valves on the same stems as the steam-valves. The valves are to be worked by a differential screw-motion, so constructed that the pistons shall follow the motions of the reversing-lever. There is to be a throttle-va'ye for each steam-cylinder and a stop-cock in the bye-pass pipe of each hydraulic cylinder. The reversing-lever is to be conveniently situated at the working-platform, and is to be fitted with a spring-catch engaging in notches in a sector—these notches being plainly marked for the ahead and astern motion and for the various grades of expansion. The reversing-lever will be connected by rods and bell-cranks to the valve-gears of both reversing-engines.

There will be at the working-platform a clamping-lever for each main-engine valve-gear. These levers will have spring-connections to keep them out of gear when thrown out, and will have spring-catches engaging in ratchet-teeth to hold them in any position desired. These levers will also be so connected with the throttles and bye-pass stop-cocks of the reversing-engines and with the clamps of the reversing-arms that the reversing-gear of either engine may be held firmly in any position by a single movement of the lever. There will also be a stop-valve in the pipe taking steam to the reversing-engines, with its wheel so situated that it may be easily reached while handling the reversing-lever. The reversing-engines to exhaust into the feed-tank or auxiliary exhaust-pipe at will, but with a change-valve which must always be open to one branch or the other. The bell-crank of each reversing-gear is to have a bar and socket for moving the reversing-gear by hand. The piston-rods and valve-stems to be of phosphor-bronze. The connecting-rods and levers to be of mild steel and pillow-blocks of cast-steel. All joint-pins and bell-crank levers to be of mild steel.

HIGH-PRESSURE EXHAUST-PIPE.

A 14-inch pipe, with proper allowance for expansion, will connect the high-pressure exhaust-nozzle with the low-pressure valve-chest.

GOVERNOR-THROTTLE.

The high-pressure exhaust-pipe will contain a pivoted throttle-valve of approved design, to be worked by the governor.

LOW-PRESSURE EXHAUST-PIPE.

The exhaust-pipe from the low-pressure valve-chest to the condenser will be of copper, 16 inches internal diameter.

MAIN PISTONS.

The main pistons will be of composition, with double shells, well ribbed. The thickness of metal in shells to be $\frac{7}{16}$ inch and that in bosses around piston-rods $1\frac{1}{4}$ inches. Each piston will have two cast-iron wearing-rings $4\frac{1}{4}$ inches wide each, upon which it will rest; these rings to be so fitted that any part of the circumference can be adjusted to take the wear. The packing-rings, one for each piston, will be $\frac{3}{8}$ inch thick and 2 inches wide, and will be adjusted by steel springs of proper tension. The followers are to be 1 inch thick, and secured in place by eight wrought-iron bolts for low-pressure piston and six for the high-pressure piston, all to be $1\frac{1}{4}$ inches diameter. All core-plugs to be in the peripheries of pistons.

MAIN PISTON-RODS.

The piston-rods are to be of steel, finished to a diameter of $4\frac{1}{2}$ inches for the high-pressure cylinder and $3\frac{1}{4}$ inches diameter for the low-pressure cylinder. They will be fitted to the pistons and secured by closed counter-sunk composition-nuts locked in position, and to cross-head and to cross-tail by open wrought-iron nuts, as shown in drawings.

PISTON-ROD STUFFING-BOXES.

The piston-rod stuffing-boxes will be made of composition, and fitted with approved metallic packing, with approved device for adjustment while the engines are in motion.

CROSS-HEADS.

The cross-heads will be of forged steel, finished all over. Each will be firmly secured to a cast-iron saddle which will have a composition slipper 18 inches wide, 20 inches long, and $\frac{1}{2}$ inch thick, secured in place by a flange and four wrought-iron bolts, as shown. Each cross-head journal will be 8 inches long, accurately turned to $5\frac{1}{2}$ inches diameter.

CROSS-HEAD GUIDES.

Each cross-head will move on a cast-iron guide fitted with two composition backing-guides 3¼ inches wide, each secured by 7 wrought-iron 1-inch bolts. Each cross-head guide will be cast in one piece and will be securely bolted to engine-keelsons.

CROSS-TAIL.

The cross-tail of the high-pressure engine will be made of steel finished all over. Each end is to be fitted with top and bottom brass gibs 8 inches long and 3½ inches wide, which are to travel on guides cast on the high-pressure engine-frames.

SIDE-RODS.

The cross-tail will be connected to its cross-head by two side-rods 3¼ inches diameter, of mild steel, finished all over. The ends of the rods are to be tapered from 3¼ inches to 2¾ inches, accurately fitted into the eyes of cross-head and cross-tail, and secured to them by finished wrought-iron nuts having recessed collars secured by steel set-screws.

CONNECTING-RODS.

The connecting-rods are to be made of forged steel, finished all over. They will be 66 inches long between centers, 4¼ inches diameter in neck at cross-head end, 4¾ inches at crank-pin end, and 5¾ inches at middle of body of rod. The caps will each be secured by two mild-steel bolts 2½ inches diameter, fitted with steel collar-nuts recessed into the caps and secured by steel retaining-screws.

CONNECTING-ROD BRASSES.

The brasses at the cross-head end of each connecting-rod will be 1 inch thick and at the crank-pin end 1¼ inches thick, the latter being lined with approved anti-friction metal in dove-tailed strips. The top and bottom lips of each crank-pin brass

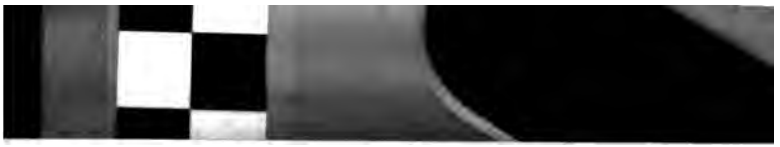
will be secured to connecting-rod end or cap, as the case may be, each by two 1¼-inch wrought-iron bolts, tapped into the brass. The heads of these bolts to be recessed into rods and caps and secured by set-screws.

CYLINDER RELIEF-VALVES.

There will be an automatic relief-valve, of not less than 4 inches diameter, located near the bottom at each end of each cylinder. These valves will be kept on their seats by spiral springs with approved method of adjustment; the springs to be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves to be guided by loosely-fitting wings. The springs are to bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles to be so fitted that the valves can be moved by the application of a lever. The valves to be fitted with casings which will prevent danger of people being scalded by hot water from the cylinders and prevent steam and water reaching the valve-springs. Suitable fulcrums to be on casings for the application of levers for working the valves; one lever to be furnished. All springs to pass a satisfactory test.

CYLINDER DRAIN-COCKS.

There will be fitted to each end of each cylinder, as low as possible, a drain-cock of approved design with 1¼ inches opening. These cocks to have bottoms cast in their shells and to have stuffing-boxes at large end. The shells to have set-screws with conical points bearing against the bottoms of cocks to prevent setting fast. The cocks to be so fitted as to be easily overhauled. All the drain-cocks will discharge into a pipe leading to the fresh-water side of the condenser, with a non-return valve. A branch from this pipe will lead to bilge with non-return valve. A cock or valve at the junction of the two branches will be so fitted that one branch must always be open. Both cocks on each cylinder to be operated by one lever at the working-platform.



inders and pillow-blocks after they are secured in place in the vessel, and will be firmly bolted to them by 2¼-inch body-bound steel bolts with wrought-iron nuts.

SHAFTS.

The crank, line, thrust, and propeller-shafts will be of mild steel, finished all over. Each length will be forged solid and have a 3-inch hole drilled axially through it from end to end. The diameter of all shafting to be 9 inches.

CRANK-SHAFT.

The crank-shaft will be forged with cranks at right angles. The main journals will be finished 9 inches diameter and 18, 23, and 18 inches long, respectively. The crank-webs will be 5½ inches thick. The cranks will be finished to a throw of 16½ inches, with crank-pins 9 inches diameter and 12 inches long having 3-inch axial holes. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and, when finished, will be tested and their accuracy proved. The eccentrics will be 4 inches wide and 16¾ inches diameter, with their centers 188° in advance of the adjoining cranks. A crank with 9 inches throw will be fixed on the forward end of shaft to work the air-pump. The shaft will be about 10 feet 9 inches long over all.

LINE-SHAFT.

The line-shaft will be made in two sections, connected by a disengaging-coupling, the ends of the sections being increased in diameter to receive the coupling-discs. The forward and after sections will be about 6 feet 3 inches and 19 feet 3 inches long, respectively.

THRUST-SHAFT.

The thrust-shaft will be about 9 feet 9 inches long, and will have 8 thrust-collars 12⅜ inches outside diameter and 1¼ inches thick, with 1⅜-inch spaces.

PROPELLER-SHAFT.

The propeller-shaft will be about 23 feet long. It will be covered, from 3 inches inboard of the stuffing-box gland to 1 inch within the propeller-hub, by a water-tight composition casing, shrunk on and pinned in place, and smoothly turned. Abaft the casing the shaft will taper 1 inch in 20 for a length of 21 inches, and will be fitted with two steel feather-keys $1\frac{1}{2}$ x $1\frac{1}{2}$ inches in cross-section. Abaft this the shaft will be threaded and fitted with a closed finished composition-nut, formed to a fair water-line from the propeller-hub.

SHAFT-COUPLINGS.

All lengths of the main shafting, except the two sections of line-shaft, will be coupled together by flange-couplings 21 inches diameter, forged on their respective shafts. All these couplings to be $2\frac{1}{4}$ inches thick except that on crank-shaft, which will be $2\frac{1}{2}$ inches thick. The bolt-holes will be equally spaced and accurately drilled to template, or in place, to 2 inches diameter, six in each coupling. The bolts will be of mild steel, finished and snugly fitted, with finished steel nuts.

DISENGAGING-COUPLING.

The disengaging-coupling discs will be made of cast-iron, each with four lugs projecting 3 inches. The radial faces of the lugs of one disc will be of steel and the opposite ones of composition, neatly fitted to each other. The fixed disc of the coupling will be keyed to the forward section of the line-shaft, and will have holes 2 inches diameter near the circumference, about 6 inches apart, for the jacking-pins, which are to be of steel 9 inches long. This disc will be 47 inches diameter, turned on its circumference, and will have a wrought-iron band 1 inch thick and 5 inches wide, bored and shrunk on. The hub will be turned to a diameter of 14 inches, with a wrought-iron band 1 inch thick and $3\frac{1}{2}$ inches wide, bored and shrunk on. It will be bored to fit the shaft, and will be

secured to it by two steel keys of $1\frac{1}{2}$ x $1\frac{7}{8}$ inches in cross-section. The sliding-disc will be 31 inches diameter, and will be strengthened by a wrought-iron band 1 inch thick and 3 inches wide; also by two wrought-iron bands on the hub, 2 inches thick by 2 inches wide, the space between the two last rings to form a circular groove $4\frac{1}{2}$ inches wide for a loose collar. The disc will be prevented from turning on the shaft by two feather-keys of $1\frac{1}{2}$ x $1\frac{7}{8}$ inches section, secured in the shaft. The sliding-disc is to be thrown in and out of gear with the stationary disc by means of a loose collar of cast-iron fitting the groove; which collar will be attached to a system of levers and worked by a tackle.

PROPELLER-SHAFT BRAKE.

A cast-iron wheel, turned 30 inches diameter and 3 inches face, will be bolted between the thrust and propeller-shafts by the coupling-bolts. It will be surrounded by a wrought-iron friction-band, with suitable levers, screw, and hand-wheel for holding the shaft tightly.

JACKING-BLOCKS.

Suitable blocks will be provided under the fixed portion of the disengaging-coupling to support the jacks used in turning the engine. They will have their tops finished as directed, and will be so fitted as to distribute the strain well over the frames of hull.

LINE-SHAFT PILLOW-BLOCKS.

There will be three line-shaft pillow-blocks, of cast-iron, between crank-shaft and thrust-bearing, with bottom brasses 18 inches long and 1 inch thick, bored to the diameter of the shaft. The cap of each pillow-block will be of cast-iron, bored to fit the shaft, and will have cast on its upper surface an ample oil and grease-cup, divided into two parts, with hinged covers, and fitted with tubes and wick-holders, with a hand-

hole between cups for examining the journals. These pillow-blocks will be securely bolted to foundations built in the vessel and will be fitted with keys for lateral adjustment.

THRUST-BEARING.

The thrust-bearing will be made of cast-iron suitably cored for circulating water through it, and fitted with composition rings, in halves, $1\frac{3}{8}$ inches thick, to match the grooves between collars of thrust-shaft. The rings will be prevented from turning in their seats by liners secured in place by the cap. The cap will be made with lugs locking into the thrust-block, and with ample oil and grease-cups, with hinged-covers, fitted with tube and wick-holder for each ring. The cap to be secured in place by four wrought-iron bolts, $1\frac{1}{4}$ inches diameter, with suitable nuts. The thrust-block will rest on a foundation built in the vessel, to which it will be secured by four wrought-iron bolts 2 inches diameter. This block to be adjustable in any direction by suitable keys.

A drain-pipe from the water-spaces will run to engine-room bilge.

STERN-TUBE BEARINGS.

At each end of the stern-tube, which will be bored $12\frac{1}{4}$ inches, will be fitted a composition lining, divided in halves longitudinally, and secured by a flange and Tobin's-metal bolts. The linings will have sections of lignumvitæ, 2 inches wide, bearing on end of grain, dovetailed in, and bored to fit the shaft loosely. The lignumvitæ is to project about $\frac{3}{8}$ inch above the surface of the composition lining, and is to be well secured in place. The length of bearing at outboard end is to be not less than 4 feet and at forward end not less than 3 feet. A steel sleeve made in halves, and fastened to boss of stern-post by countersunk screws, will form a fair water-line from stern-post to hub of propeller.

STERN-TUBE STUFFING-BOX.

At the inboard end of the stern-tube a composition stuffing-box will be bolted, having a packing space, 7 inches deep, for one-inch packing. The gland will be in two parts, with $1\frac{1}{4}$ inches space between them. The gland-studs to be of Tobin's metal with lock-nuts. A $1\frac{1}{4}$-inch drain-cock will be fitted on after end of stuffing-box, outboard of the packing, with a pipe leading to the engine-room bilge.

SCREW-PROPELLER.

The propeller will be about 9 feet 9 inches diameter and about 12 feet mean pitch. It will be made of manganese bronze, right-handed, with three blades having a total surface of about 23.5 square feet. It will be cast as smooth as possible and will have any roughness removed. The hub will be faced and will be bored to accurately fit the taper of the propeller-shaft, to which it will be secured by two feather-keys $1\frac{1}{2}$ x $1\frac{1}{2}$ inches in cross-section and about 21 inches long. The joint between shaft-casing and hub to be made water-tight. The propeller will be firmly held on the shaft by a nut, elsewhere specified, which will be set up to a water-tight joint and well locked in place. All to conform to drawings.

MAIN CONDENSER.

The condenser-shell will be cylindrical, built up of sheet-brass or Muntz metal $\frac{1}{4}$ inch thick, well stiffened by composition angle or T-rings, and with composition flanges for the tube-sheets. The tube-sheets are to be of composition or Muntz metal, 1 inch thick, drilled to fit the tubes loosely, counterbored $\frac{3}{16}$ inch, and tapped to receive the glands. The glands will be of composition and turned over at ends to prevent crawling of tubes; they will be slotted at outer ends for convenience in screwing into place. Tube packing to be of approved kind. There will be 1,370 seamless-drawn brass tubes, $\frac{5}{8}$ inch outside diameter, No. 20 B. W. G., spaced $\frac{15}{16}$ inch between centers,

they will be 11 feet long between tube-sheets, giving a condensing surface of 2,466 square feet. The tubes will be suitably supported by brass plates ¼ inch thick, well secured to condenser-shell. There will be horizontal deflecting plates so arranged that they, together with the supporting plates, will cause the steam to pass equally over the whole of the condensing surface. The exhaust and discharge-nozzles, the water-chests at ends, man-hole frames, covers, and facings for attachment of fittings will be of composition, riveted or bolted on, as may be directed. No flanges are to be less than 2½ inches wide. All composition parts are to be as light as consistent with sufficient strength and stiffness.

The exhaust-nozzle will be so made that the steam cannot impinge directly upon the tubes. It will contain a 3-inch brass pipe perforated for spraying the salt-feed water, and fitted with a stop-valve; it will have facings for attachment of the bleeder and auxiliary exhaust pipes. The areas of cross-section of the exhaust and air-pump suction-nozzles will be 201 and 40 square inches, respectively. The air-pump suction-nozzle will be connected directly to the air-pump casing. The circulating-water chest at the inlet end will be divided by a horizontal diaphragm. This diaphragm will be fitted with a straightway valve of sufficient opening to allow the water from the circulating-pump to pass overboard, without passing through the tubes, when required. This valve to have suitable gear for working it and holding it in any position.

The inlet and outlet openings for circulating water will each have a cross-section of not less than 80 square inches. There will be a man-hole in each division of water-chest and one in bottom of fresh-water side.

There will be a copper tank, pipe, and cock fitted for the purpose of admitting an alkaline solution into the exhaust-nozzle. The salt-feed pipe, if required, will be connected to the fire and bilge-pump for the purpose of filling the steam side of the condenser. An air-cock will be fitted on the highest part of condenser-shell. A connection from the auxiliary steam-pipe will be made to the bottom of the con-

denser to clean the tubes by boiling. Drain-cocks will be fitted on salt and fresh-water sides where required, with pipes leading to bilge. The condenser must be perfectly tight in all joints, and be so proved after being secured in place. It will rest on the air-pump at the forward end, and be supported by approved means at middle and at after end, and firmly secured.

AIR-PUMP.

There will be an inclined cylinder double-acting air-pump worked by a crank on the forward end of crank-shaft; it will have a cylinder diameter of 14 inches and a stroke of 18 inches. All parts, except as noted, will be made of composition as light as possible consistent with strength. The channel-ways, valve-chambers, and cylinder will be in one casting. Valve-seats to be properly faced and bolted in place. The suction-nozzle will be made to match the corresponding nozzle on condenser. There will be two 7-inch delivery-nozzles connected to each other and to the feed-tank by a 7-inch pipe.

There will be 13 suction and 12 delivery-valves at each end of pump, with 4 inches diameter of opening. The valves to be of hard vulcanized rubber, and to have approved springs on top. The pump-piston will have efficient metallic packing. The pump piston-rod will be made of rolled phosphor-bronze, $2\frac{1}{2}$ inches diameter, secured in the piston by a composition collar-nut well locked in place; it will engage with a cross-head working in cast-iron guides bolted to the pump-casing. The stuffing-box will be fitted for either metallic or ordinary packing. The pump connecting-rod will be of forged steel $2\frac{1}{2}$ inches diameter in the necks, with ends, as shown, adjustable for wear. The pump-casing will be securely bolted to the seating provided for it, and will form a support for the forward end of condenser.

The air-pump, together with the condenser, must maintain a vacuum of within four inches of mercury of the weather barometer with the propelling-engines at full power under forced draught.

CIRCULATING-PUMP.

The circulating-pump will be of the centrifugal type, of approved design, made of composition, and capable of discharging 3,000 gallons of water per minute against a head equal to the vessels draught when using steam of not over 70 pounds boiler-pressure. The pump to be connected to take water from the sea or bilge at will; it will be located as shown in drawings, and will be operated by a special engine of approved design. The suction and delivery-nozzles will be 10 inches internal diameter.

FEED-TANK.

The fresh-water feed-tank will be made of wrought-iron plate not over $\frac{3}{16}$ inch thick, to have a capacity of not less than 200 gallons. The tank to be properly secured in the engine-room. It is to be fitted as a filter, and will be provided with a vapor-pipe, a float-valve for preventing access of air to feed-pumps, a suitable overflow-pipe, and a glass gauge.

BOILERS.

There will be two cylindrical, horizontal, direct fire-tube boilers, 8 feet 8 inches greatest diameter and 18 feet $4\frac{1}{2}$ inches long, the back end of each boiler being reduced to 8 feet 1 inch diameter for a length of 7 feet $3\frac{1}{2}$ inches. Each boiler will have two cylindrical furnaces 40 inches least internal diameter. The boilers will be placed side by side with their longitudinal axes fore and aft; they will carry a working pressure of 100 pounds per square inch by gauge. The fire-room is to be abaft the boilers.

BOILER MATERIAL.

All parts of the boilers, except as otherwise noted, will be of open-hearth mild steel. The tubes will be of the best wrought-iron.

BOILER-SHELLS.

The boiler-shells will be made of $\frac{5}{8}$-inch plates in the part having the larger diameter, and of $\frac{9}{16}$-inch plates in the part of lesser diameter; the joints to be as shown in drawings.

BOILER-HEADS.

The front heads are to be $\frac{1}{2}$-inch thick, each to be made in two pieces, the lower piece or furnace-plate to be flanged out and the upper or curved plate to be flanged in, the joint between the two to be made with a welt 1 inch thick, as shown in the drawing; the back heads to be each formed of two $\frac{1}{2}$-inch plates, both flanged in, and united by a welt of same thickness as that of front head. These two welts to extend into boiler, as shown, for the attachment of the braces. The front head will be flanged outwardly for attachment of furnace-flues. The upper plate of front head will be rounded to a radius of $34\frac{3}{4}$ inches as shown, the upper plate of back head to $31\frac{1}{4}$ inches, and the lower plate of back head to $11\frac{3}{4}$ inches.

BOILER TUBE-SHEETS.

The lower plate of the back head will form the back tube-sheet. The front tube-sheet will be the back plate of the combustion-chamber, $\frac{1}{2}$ inch thick. The tube-sheets must be accurately parallel, 7 feet 10 inches apart. The tube-sheets of each boiler will be drilled for 22 stay-tubes and 176 ordinary tubes, as shown, and tapped in place for the stay-tubes. All tube-holes are to be slightly rounded at edges.

COMBUSTION-CHAMBERS.

The combustion-chambers are to be $9\frac{1}{4}$ inches deep, made of $\frac{7}{16}$-inch plates, except tube-sheet, which is to be $\frac{1}{2}$ inch thick. The bottoms to be supported by brackets, as shown in drawing. The front plate of each combustion-chamber to have two stay-domes as shown.

BOILER-TUBES.

The tubes are to be lap-welded, of the best wrought-iron. Every fourth tube vertically and every third tube horizontally will be a stay-tube. The stay-tubes will be $2\frac{3}{4}$ inches external diameter and $\frac{5}{16}$ inch thick; they will be swelled to 3 inches diameter at the back ends; they will be screwed into both tube-sheets, being screwed up to a tight joint in the combustion-chamber tube-sheet and made tight at the other end by a wrought-iron nut. The ordinary tubes will be 3 inches external diameter, No. 11 B. W. G., and will be swelled to $3\frac{1}{16}$ inches diameter at the back ends; they will be expanded in the tube-sheets by approved expanding-tools. The above method of tube setting to be subject to change if directed.

BOILER-BRACING.

There will be seven $2\frac{1}{4}$-inch stays from end to end of each boiler, attached to the welts of heads by 2-inch pins, as shown: each stay to be in two parts, also joined by pins. There will be two $1\frac{1}{2}$-inch stays from the front head of each boiler to the combustion-chamber; they will be secured to front head by nuts and washers, and to combustion-chamber plate by concave and convex nuts turned to fit curves of stay-domes. Two gussets of $\frac{1}{2}$-inch plates will be riveted to double angles on front head and shell of each boiler on each side of man-hole. The braces to be entirely without welds.

RIVETED-JOINTS.

The longitudinal joints of boiler-shells will be double-strapped and double-riveted on each side of seams. The circumferential joints to be single-strapped and double-riveted. The joints between shells and heads, and between the head-plates and welts, will be double-riveted. All other joints will be single-riveted. The proportions of joints to be as directed. All plates where possible are to be planed on their edges. All joints will be calked inside and out. All rivet-holes are

to be drilled in place, or to be punched $\frac{1}{8}$ inch small and reamed in place to proper size. Hydraulic riveting to be used wherever possible.

BOILER MAN-HOLES AND PLATES.

There is to be a 15 x 12-inch man-hole in the lower part of front head of each boiler; it will have a strengthening ring of 3 x $\frac{1}{2}$-inch iron riveted on, and will be fitted with a cast-steel plate with two wrought-iron dogs and bolts. There is to be a 15-inch circular man-hole in the rounded part of front head of each boiler; it will have a cast-steel frame riveted to boiler-head and a cast-steel cover bolted to frame.

FURNACES.

The furnaces will be corrugated, with welded joints, made of $\frac{7}{16}$-inch plates. They will be 40 inches least internal diameter and 44 inches greatest external diameter. They must be perfectly circular in cross-section at all points. They will be flanged at back ends for attachment to combustion-chambers. The length of each furnace-flue will be about 9 feet 7$\frac{1}{4}$ inches over all.

FURNACE-FRONTS.

The furnace-fronts are to be made with channel-iron frames covered with wrought-iron plates; the inner plates to be $\frac{1}{4}$ inch thick and the outer ones $\frac{3}{8}$ inch thick; both plates to be suitably perforated for air entry if so directed. The dead-plates will be made of cast-iron, so fitted as to be easily removable.

FURNACE-DOORS.

The furnace-doors are to be made with wrought-iron fronts $\frac{1}{4}$ inch thick; to have holes for admission of air, and dampers or regulators to cover them; each to be fitted with perforated wrought-iron inner plate, and with hinges and latches of wrought-iron.

ASH-PIT DOORS.

The ash-pit doors are to be made of wrought-iron $\frac{1}{8}$ inch thick, flanged 1 inch deep; to be well fitted to close the ash-pits, and arranged to hang by proper hooks on bulkheads when not in use.

ASH-PANS.

Loose ash-pans of $\frac{1}{4}$-inch wrought-iron will be fitted to all furnaces, reaching from front of furnace to bridge-wall.

BRIDGE-WALLS.

A cast-iron bridge-wall of approved pattern will be fitted in each furnace. The upper part will be finished with fire-brick. The lower part, below the grate-bars, to be furnished with an inclined hinged door at least 6 inches high and as wide as possible, so made as to be easily opened and shut from fire-room. The bridge-walls to be easily removable.

GRATES.

Each furnace will have a grate 40 inches wide and 7 feet long, making a total grate surface, in both boilers, of 93.2 square feet.

GRATE-BARS AND BEARERS.

The principal grate-bars are to be of wrought-iron, in one length, of approved pattern. They will be arranged to be shaken from the front ends by proper tools; these tools to be furnished for all furnaces. The bars at sides of furnaces to be of cast-iron to fit the corrugations. The bearers to be of wrought-iron supported by lugs bolted to furnaces.

LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the front of each ash-pit.

CIRCULATING-PLATES.

Circulating-plates of $\frac{1}{8}$-inch galvanized wrought-iron will be fitted in the boilers, at sides of tubes and furnaces, as may be directed. They will be made in sections not over 14 inches wide and will be securely attached to the braces.

UPTAKES.

The uptakes are to be made with double shells of wrought-iron, built on frames of $2\frac{1}{2}$ x $1\frac{1}{2}$ inches channel-iron; the inside and outside plates to weigh 5 pounds and 3.8 pounds per square foot, respectively. The space between the plates to be filled with an approved incombustible non-conducting material. The walls of the uptakes of the two boilers will join each other at about the middle of the height of the boilers, but a fore-and-aft partition will separate the gases. The uptake will be rectangular in cross-section at the protective-deck, and will be attached to the smoke-pipe so as to allow for expansion.

UPTAKE DOORS.

The uptake doors will be made of wrought-iron with double shells, the outer plates being $\frac{1}{4}$ inch and the inner plates $\frac{1}{8}$ inch thick. The outside plates will be flanged one inch and the inner ones $2\frac{1}{4}$ inches. The spaces to be filled with non-conducting material, same as in walls of uptakes. Wrought-iron hinges and latches to be fitted.

SMOKE-PIPE.

The smoke-pipe will be 41 feet 6 inches high above the grates; it will be made of wrought-iron plates, the lower courses to be No. 8 B. W. G. and the upper ones No. 9 B. W. G. The pipe will be 4 feet 6 inches internal diameter, expanding in the lower part to rectangular form, 4 feet 11 inches by 6 feet, where it joins the uptake. It will be so supported as not to throw any of its weight on the uptake.

It will be divided from the bottom to near the top by a fore-and-aft division plate. It will be surrounded from bottom to top by a jacket, 5 feet in diameter, made of plates No. 11 B. W. G. The jacket-space will be covered by a hood, with sufficient intervening space for the escape of hot air. All joints to be butted and strapped. Suitable stays, eyes, and shackles will be fitted. A permanent outside ladder reaching to top of pipe will be fitted as directed.

SMOKE-PIPE DAMPERS.

Each division of the smoke-pipe, near the top, will be fitted with a hinged damper, which will also serve as a cover. A drain-trough will be fitted below the dampers, with a drain-pipe leading where directed. The dampers are to be worked, by approved mechanism, from the fire-room.

STEAM-JET.

A steam-jet of approved design will be provided, and fitted in the smoke-pipe.

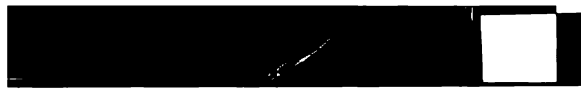
BOILER-SADDLES.

Each boiler is to rest in three wrought-iron saddles thoroughly secured to the hull. The boilers will be bolted or riveted to double angle-irons riveted to saddles.

BOILER-ATTACHMENTS.

Each boiler will have the following attachments and fittings, viz:

One main steam stop-valve;
One auxiliary steam stop-valve;
One dry-pipe;
Two feed check-valves, with internal pipes;
One surface blow-valve, with internal pipe;
One bottom blow-valve, with internal pipe;
One safety-valve;



One steam-gauge;
Two glass water-gauges;
Four gauge-cocks;
One sentinel-valve;
One salinometer-pot;
Two drain-cocks;
One air-cock;
One hydrokineter or equivalent.

All external fittings, unless otherwise directed, will be made of composition. No fittings will be screwed into the boiler-plates, but will be flanged and through-bolted, or attached in other approved manner. All cocks, valves, and pipes will have nipples passing through the plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the plates nowhere except where attached to shell. The internal feed and blow-pipes will be arranged to come between the corrugations of furnaces. Bolts for attaching boiler fittings will, where possible, be screwed through the boiler-plates, with heads inside.

BOILER MAIN STOP-VALVES.

The main stop-valve on each boiler will be a self-closing valve, with horizontal spindle, having an opening $7\frac{1}{2}$ inches in diameter. The valve-chamber will have a flange curved to shape of boiler-head, to which it will be bolted. A screw-sleeve with a 14-inch hand-wheel will be fitted for closing the valve. Separate provision is to be made for closing each valve from the upper deck. Each valve-chamber will have, below the valve-seat, a facing for attachment of the auxiliary stop-valve. The chamber of each valve will have a flange for the attachment of the athwartship steam-pipe; the starboard stop-valve will also have a flange for attachment of the main steam-pipe.

BOILER AUXILIARY STOP-VALVES.

The auxiliary stop-valve on each boiler will be a $3\frac{1}{2}$-inch screw stop-valve, and will be bolted to the facing provided on the main stop-valve chamber.

DRY-PIPES.

There will be in each boiler, as high as possible and properly supported, a 7½-inch brass dry-pipe extending nearly the length of the boiler, perforated on top with ⅜-inch holes, with a total area equal to twice the cross-section of the pipe. The front end of the pipe will be flanged and bolted to the boiler by the stop-valve bolts. The pipe to be closed at the inner end, and to have a ½-inch drain-hole in bottom near each end.

FEED-CHECK VALVES.

Each boiler will have two 2½-inch screw feed-check valves. The internal feed-pipes will lead downward to near the bottom of boiler.

BLOW-VALVES.

Each boiler will have a 2-inch bottom-blow valve with internal pipe leading to near bottom of boiler, and a 1½-inch surface-blow valve with an internal pipe leading to the center of the boiler with openings about one-inch above the highest heating surface.

SAFETY-VALVES.

Each boiler will have an adjustable 5-inch spring safety-valve, with nickel seat, adapted to the boiler pressure, and fitted with approved mechanism for working it from the fire-room and engine-room; the valve fittings to be so constructed that the valve can be overhauled without slacking the spring, and so that escaping steam will not come in contact with the spring. The valve will be cased in, with a flange on its case for attachment of the escape-pipe. The seats of the safety-valves will be raised at least ½ inch above the bottoms of the casings, to which drain-pipes, leading to bilge, will be attached.

SENTINEL-VALVES.

There is to be a sentinel-valve of ½ square inch area attached *to the front* end of each boiler, fitted with movable weight

and notched lever, and weighted to close tightly against a boiler-pressure of 150 pounds per square inch.

WATER-GAUGES.

There will be on the front of each boiler two water-gauges with outside 1-inch pipes running to top and to near bottom of boiler, with valves close to boiler. Each gauge will have shut-off and blow-out cocks with at least ½ inch openings, and with handles at least 6 inches long, hanging down when in working position. Each glass will be about 16 inches in exposed length, and will be fitted with easily accessible stuffing-boxes and glands. The bottoms of exposed parts of glasses to be 1 inch below the highest heating surface. The glasses to be well protected. The blow-out cocks will have drain-pipes. The position of the highest heating surface to be plainly indicated on the gauge fittings.

GAUGE-COCKS.

There will be on each boiler, entirely independent of the glass gauges, four gauge-cocks of approved pattern, spaced 6 inches apart, the lowest cock to be about 4 inches below the highest heating surface. The cocks to have drip-pans and drain-pipes, and to be easily worked from the fire-room.

BOILER STEAM-GAUGES.

There will be a Lane's improved spring steam-gauge for each boiler, placed where directed, and connected to the boiler by an independent pipe, which is to be entirely in sight from the fire-room. Each gauge is to be graduated to 150 pounds and to have an 8½-inch dial.

SALINOMETER-POTS.

There is to be a salinometer-pot of approved pattern for each boiler, fitted in an accessible position.

BOILER-DRAINS.

There will be a 1-inch drain-cock or screw-plug, as directed, fitted to each end of each boiler.

HYDROKINETERS.

There will be connected to each boiler a Weir's hydrokineter, or other approved appliance for circulating water in the boiler while raising steam; proper connections being made to auxiliary steam-pipe.

BOILER AIR-COCKS.

A ½-inch cock or valve will be fitted to the highest part of each boiler, with pipe leading to bilge.

ZINC BOILER-PROTECTORS.

Each boiler will have not less than twelve rolled-zinc plates about ½ inch thick, each about 6 x 12 inches or equivalent, suspended from the braces in iron wire-gauze baskets. Perfect metallic connection will be made between the zinc plates and the braces by iron straps bolted to the zincs and clamped to the braces. All points of contact to be filed bright before attachment, and the joints afterwards made water-tight by paint or approved cement.

AIR-TIGHT FIRE-ROOM.

Supplementary bulkheads and ceilings of light galvanized iron are to be fitted in the fire-room for the purpose of reducing the space to be put under air-pressure. The ceiling is to be made movable beneath hatches. The vertical portion to be worked in about the boiler fronts. All permanent and temporary joints and seams to be made perfectly air-tight. These bulkheads to have openings where required, with suitable means for closing them. Suitable allowance for expansion will be made where bulkheads are attached to boilers and uptakes.

BLOWERS.

There will be two Sturtevant blowers, or equivalent, in each fire-room. Each blower, together with its engine, must be capable of supplying continuously to the fires 10,000 cubic feet of air per minute under a pressure of 4 inches of water. The blowers will take air from the fire-room ventilators and will deliver directly into the fire-room; one blower will also be connected to draw air from the engine-room. Means will be provided for closing either ventilator in case its blower is stopped.

BLOWING-ENGINES.

Each blower will be driven direct by a two-cylinder or three-cylinder engine, as may be directed, of approved design and of sufficient power to run the blower at full speed with steam of 60 pounds pressure. The engines must be sufficiently compact to leave plenty of head-room underneath, and must have all working parts closed in but easily accessible for overhauling. The throttle of each engine is to be fitted to be worked from the fire-room floor.

AIR-PRESSURE GAUGES.

An approved gauge will be fitted in the fire-room to show the excess of air-pressure over the pressure of the open atmosphere. A portable gauge will also be supplied, with conveniences for attaching it to the furnaces, uptakes, and where directed, to measure the pressures as compared with the pressure in the fire-room. All these gauges are to indicate pressures in "inches of water."

FIRE-TOOL RACKS.

Racks will be fitted in the fire-room, in convenient places, for holding all necessary fire-tools.

MAIN FEED-PUMP.

There will be in fire-room, where shown on drawings, a vertical duplex pump of approved design, with a maximum

capacity of 100 gallons per minute, and with steam-cylinders of sufficient size for the work required. It will draw from the sea, feed-tank, or bottom of condenser, at will, and will deliver only into main feed-pipe.

AUXILIARY FEED-PUMP.

A duplicate of the main feed-pump will be fitted, but will be connected to draw from sea, feed-tank, bilge, or boilers, at will, and to deliver either into auxiliary feed-pipe or fire-main, through distillers, or overboard.

ASH-HOIST.

A circular trunk, 21 inches internal diameter, will lead from the fire-room to about 18 inches above the main-deck for hoisting ashes. It will be made of wrought-iron, No. 10 B. W. G., butted, strapped on outside and flush-riveted inside. It will be fitted with approved means of closing at upper and lower ends so that ashes can be hoisted when there is an air-pressure in the fire-room. An ash-hoisting engine of approved design is to be fitted, of sufficient power to hoist 150 pounds from the fire-room floor to the deck in five seconds with steam of 20 pounds pressure. It will have reversing-gear worked from fire-room or from deck, as may be directed, with approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor. Also to be fitted with an approved brake to control the drum.

The ash-hoist will be fitted with the necessary sheaves, whip, and all appliances for handling ash-buckets complete.

ASH-DUMPS.

From the top of the ash-hoist permanent overhead rails, suitably supported, will lead to the ash-chutes on both sides of the vessel. Each of these will be fitted with a traveler of approved design, with all necessary appliances for handling the buckets. At the top of each ash-chute a dumping-hopper will

be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping-gear is to be such that the buckets will not have to be lifted by hand.

STEAM-TUBE CLEANER.

A steam-tube cleaner will be supplied and fitted with all connections complete. It is to be of sufficient length to clean the tubes from the fire-room ends, through furnaces or ash-pits. It is to be fitted with a wooden handle and to be stowed in a convenient rack. It will take steam from the auxiliary steam-pipe.

AUXILIARY CONDENSER.

There will be in the engine-room, suspended from the deck beams, an auxiliary condenser, with not less than 175 square feet of cooling surface, into which the auxiliary exhaust-pipe can discharge when desired. The condenser-shell will be cylindrical, of copper, with composition flanges, tube-sheets, chests, covers, and nozzles. The tubes will be fitted as in the main condenser. The cooling water will be forced through the tubes by the engine-room bilge and fire-pump. The condensed water will drain into the feed-tank.

BILGE AND FIRE-PUMP.

A horizontal steam-pump of approved design will be fitted in the engine-room. It will have steam and water cylinders of 12 and 7 inches diameter respectively, and a stroke of 12 inches, or be of equivalent commercial size. It will draw water from sea or engine-room bilge, at will, and will deliver into fire-main, overboard, through auxiliary condenser, or into engine-room water-service pipes, as desired.

STEAM-WINDLASS AND CAPSTAN.

There will be on the upper-deck, under the forecastle, a steam-windlass of approved design. It will be connected by suita-

ble gearing with a capstan on the forecastle, fitted with bars for working by hand; the capstan also to be driven by the windlass when required. The windlass will have two wild-cats fitted for 1¼-inch chain, each with brake and clutch. The engine must be double, with reversing-gear, and be on same deck as windlass. It must be of sufficient power to raise both bower-anchors at once at the rate of 6 fathoms per minute with steam of 30 pounds pressure. There must be rope-drums on both port and starboard ends of windlass-shaft. The windlass, capstan, and engines to be firmly secured in place.

The contractors for the hull will make all holes in the decks for securing the windlass and capstan, and will stow the fittings.

DISTILLING APPARATUS.

The distilling apparatus will be located as directed, and will consist of an evaporator and a distiller of approved design, of a capacity of 1,000 gallons of potable water in 24 hours. The auxiliary feed-pump will be used for circulating water through the distiller. The circulating water, after passing through the distiller, will go forward through a copper pipe for use in flushing the crew's water-closets, and a branch from this pipe with suitable valves will lead to the officers' water-closets. A bye-pass pipe with suitable valves will connect the discharge-pipe of the circulating-pump to the flushing-pipe, for use when the distiller is shut off. The pump for feeding the evaporator will have a capacity equal to a No. 0 Blake pump, and will be of the direct-acting type. The evaporator will be felted and lagged, and will be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks on pipes leading to fire-room, salinometer-pot in fire-room, a blow-valve, and an automatic feeding device of approved pattern; it will take steam from the auxiliary steam-pipe and will be fitted with an automatic trap and drain-pipes leading to feed-tank. The entire distilling apparatus to be capable of being efficiently worked from the fire-room. The distiller will be fitted with a filter, and with the pipes necessary for running the distilled water into the fresh-water tanks.

MAIN STEAM-PIPES.

A 7½-inch pipe will connect the two main stop-valves on boilers; from the starboard-boiler stop-valve a 9-inch pipe will lead to the engine stop-valve.

AUXILIARY STEAM-PIPES.

An auxiliary steam-pipe of sufficient size to supply steam to all auxiliary machinery will connect with the auxiliary stop-valves on boilers and with the main steam-pipe in engine-room and in fire-room. It will have a stop-valve in fire-room close to engine-room bulkhead. Branches will connect with the blowers, feed-pumps, bilge-pump, circulating-pump, reversing-engines, windlass, evaporator, ash-hoisting engine, radiators, steam-jet, and whistle. Stop-valves to be fitted where required. There will be a steam-gauge in brass case, with about 4½-inch dial, connected to the auxiliary steam-pipe in engine-room and at windlass.

SEPARATOR.

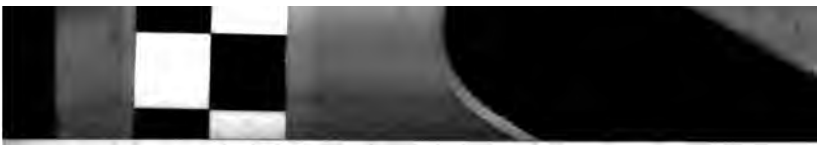
There will be, in main steam-pipe in engine-room, a composition separator of approved design, properly supported. It will have a well-protected glass gauge, and an approved steam-trap with drains delivering into feed-tank or overboard, at will.

BLEEDER-PIPE.

A 3-inch bleeder-pipe will lead from main steam-pipe to main condenser, with two stop-valves; one valve to be operated from the working-platform.

AUXILIARY EXHAUST-PIPES.

An auxiliary exhaust-pipe will be fitted with branches leading to all auxiliary engines. It will have valves to direct the exhaust-steam into main condenser, auxiliary condenser, or escape-pipe at will; where it connects with escape-pipe and auxiliary condenser, it will have double stop-valves.



including coal-bunkers. Each hose is to be fitted complete with standard brass couplings, nozzle, and spanners, and to have approved means of stowing while attached to its fire-plug.

ENGINE-ROOM WATER-SERVICE.

A 3-inch pipe in engine-room, connected with the auxiliary sea-suction valve and with the delivery of the fire and bilge-pump, will have branches leading as follows:

Two 1¼-inch pipes to each main bearing and crank-pin, and to thrust-bearing.

Two 1-inch pipes to each cross-head, and two to circulating-pump engine.

One 1-inch pipe to each eccentric and to each line-shaft bearing.

All the above to have detachable sprays or short lengths of hose, as directed.

Two 1-inch branches will be screwed into each crank-shaft pillow-block, with holes leading through brasses to tops of journals. Each branch will have a separate valve. All pipes and fittings above the floors to be of brass, polished.

SEA-SUCTION PIPES.

There will be the following suction-pipes for sea-water:

A 10-inch pipe from main injection-valve to the circulating-pump.

A 5-inch pipe from engine-room sea-suction valve to fire and bilge-pump.

A 3-inch pipe from the same valve to the salt-feed valve on condenser.

A 3-inch pipe from the fire-room sea-suction valve to the main feed-pump.

A 3-inch pipe from the same valve to the auxiliary feed-pump.

A 1-inch pipe from the same valve to the evaporator feed-pump.

FEED-TANK SUCTION-PIPES.

From the feed-tank separate 3-inch suction-pipes will lead to main and auxiliary feed-pumps, each with a stop-valve at tank and a screw non-return valve at pump.

SUCTION-PIPE FROM BOTTOM OF CONDENSER.

From the air-pump channel-way, below the foot-valves, a 2-inch pipe will lead to the main feed-pump suction-pipe in engine-room, with a screw non-return valve.

BILGE-SUCTION PIPES.

The following pipes will lead from lowest parts of bilges to the various pumps:

A 10-inch pipe from a strainer in engine-room bilge to the bilge injection-valve.

A 5-inch pipe from engine-room bilge to fire and bilge-pump.

A 3-inch pipe from fire-room bilge to the auxiliary feed-pump.

The two last-mentioned pipes to be fitted above the floor-plates with Macomb bilge-strainers, and to have screw non-return valves at pumps.

BOILER PUMPING-OUT PIPES.

A 2-inch pipe will lead from each blow-pipe, between the boiler blow-valves and the blow Kingston valve, to the auxiliary feed-pump, with screw stop-valve close to blow-pipe, for pumping out boiler.

PIPES THROUGH BULKHEADS AND DECKS.

All pipes passing through water-tight bulkheads or decks will be made water-tight by stuffing-boxes, flanges, or other approved means.

Pipes must not be led in such a manner that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, are to have brass or copper thimbles, made water-tight, extending at least 3 inches above decks.

PIPES THROUGH COAL-BUNKERS.

All pipes passing through coal-bunkers are to be cased in in an approved manner.

THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Main steam-pipes	No. 5
Auxiliary steam-pipes of 4½-inch bore	No. 9
Auxiliary steam-pipes of 3½-inch bore	No. 10
Auxiliary steam-pipes of 3-inch bore	No. 11
Auxiliary steam-pipes of 2-inch bore	No. 12
Main exhaust-pipe	No. 10
Circulating pump-suction and discharge-pipes	No. 8
Bilge-injection pipe	No. 10
Air-pump discharge to feed-tank	No. 8
Feed-pump suction-pipes	No. 11
Feed-pump delivery-pipes	No. 10
Blow-pipes	No. 7
Auxiliary exhaust-pipes	No. 12
Escape-pipes	No. 12
Fire and bilge-pump suction-pipes	No. 11
Connections to fire-main	No. 10
Salt-feed pipe	No. 16
Dry-pipes	No. 14
Internal feed and blow-pipes	No. 16
Galvanized wrought-iron bilge-suction pipes	No. 7

All pipes of which the thickness is not given in the above list will be made of approved thickness.

MATERIAL AND FITTING OF PIPES.

All pipes, except the lower ends of bilge-suction pipes, or where otherwise specified, will be of copper. All feed and blow-pipes, all bilge-suction pipes except the lower parts, and all steam-pipes less than three inches diameter, are to be seamless-drawn. All copper pipes not seamless-drawn are to be brazed. All copper pipes over 1 inch diameter will have composition flanges riveted on, calked, and brazed; under 1 inch diameter to have approved composition couplings brazed on. All feed and blow-pipes to have composition flanges. All flanges are to be faced and grooved, and joints made with approved material. All composition flanges below the floor-plates will be connected by bolts and nuts of Tobin's metal. All bends in copper pipes are to be made one gauge thicker than straight parts. All copper pipe T-pieces, and fittings are to be made of composition. Expansion-joints of approved pattern are to be fitted where required. Slip-joints, if fitted, are to have stop-bolts and flanges. The lower parts of bilge-suction pipes are to be made of galvanized wrought-iron. All copper pipes in bilges are to be well painted and covered with waterproof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and valves of ample size and with approved automatic traps discharging into feed-tank or condenser, as directed, and elsewhere if required. All traps will have bye-pass pipes and valves for convenience in overhauling. The lowest part of all water-pipes, and all pump-cylinders and channel-ways are to have drain-cocks or valves, with pipes, where required. The handles of all drain-cocks will point downward when closed.

AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close to cylinders as possible. Exhaust

stop-valves are to be straightway where practicable. All pumps except circulating-pump will have screw check-valves in both suction and delivery-pipes, close to pump-cylinders.

PUMP RELIEF-VALVES.

All pumps, except circulating-pump, will have adjustable spring relief-valves of approved design, connecting the delivery and suction passages.

SEA-VALVES.

There will be the following sea-valves:

In engine-room: A 10-inch sea-injection valve, which will be a screw-valve with india-rubber face closing against the outside pressure, with its hand-wheel at least 3 feet above the engine-room floors: A 5-inch screw stop-valve with flanges for the attachment of fire and bilge-pump suction-pipe, the salt-feed pipe, and engine-room water-service pipe: A 10-inch screw stop-valve with india-rubber face, closing against the pressure in condenser discharge-pipe, for main outboard delivery: A valve-box containing the following valves: a 4-inch screw non-return valve for fire and bilge-pump delivery; a 4-inch screw non-return valve for auxiliary condenser salt-water delivery; a $1\frac{1}{2}$-inch non-return valve for steam-trap discharge. This valve-box to be attached to starboard side of vessel near the auxiliary condenser.

In fire-room: A 5-inch screw stop-valve, with flanges for attachment of suction-pipes of main and auxiliary feed-pumps and of evaporator-pump; also for attachment of pipe to ash-sprinklers: A 3-inch Kingston-valve, with flanges for attachment of the cocks in blow-pipes; it is to have a screw-stem with a loose nut, which can be used to shut the valve when required; the stem also to have a cross-bar handle on top.

All suction-valves are to have strainers over their openings, with $\frac{3}{8}$-inch holes; the total area of the holes in each strainer to be equal to twice the area of the valve-opening. No waste-water is to be delivered above the water-line, except as noted.

ATTACHMENT OF VALVES TO HULL.

Around all holes in the skin of the vessel for attachment of sea-valves, steel strengthening-rings, not less than 1 inch thick, will be flush-riveted. To these rings the valve-casing flanges will be fastened by Tobin's-metal collar-bolts, care being taken that the bolt-holes are not drilled entirely through the steel rings. Suction-valve strainers must be fastened to the valve-casings, and not to plates of hull. Zinc protecting-rings will be fitted to all sea-valve openings, flush with skin of vessel.

BILGE-SUCTION VALVES.

All bilge-suction valves will be screw non-return valves. The main bilge-injection valve will be a 10-inch valve with its hand-wheel at least 3 feet above the engine-room floors. The other valves to correspond in size to the nozzles of their respective pumps.

COCKS AND VALVES.

All cocks and valves, and their fittings, except as otherwise specified, will be made of composition. All hand-wheels are to be of finished brass, except as otherwise specified, and will be at least one-and-a-half times as great in diameter as their valves. All cocks communicating with vacuum spaces are to have bottoms of shells cast in, and to have packed plugs. All cocks over 1-inch diameter are to have packed plugs.

Valves of approved pattern are to be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves must be so fitted as to be easily ground in, and be fitted, where necessary, with grinding-in guides and handles. No conical-faced valve must have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve-spindles must turn right-handed to close. All valve-spindles will have outside threads where practicable. Cocks and valves may, where approved, have, in lieu of wheels or permanent handles, removable box or socket-wrenches, marked

and stowed in convenient racks. All cocks and valves underneath the floor-plates are to have their wheels or handles above the floor-plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameters of the equivalent clear openings.

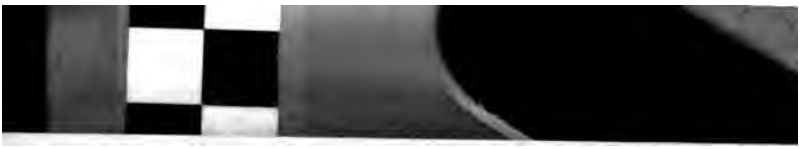
CLOTHING AND LAGGING.

The main cylinders and valve-chests, after being finally secured in place in the vessel and tested, are to be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and brass lag-screws. The lagging is to be made in removable sections over each cylinder-cover, valve-chest cover, and man-hole cover. The sections to be of such size as to be easily handled, and all parts plainly marked. The lagging elsewhere is to be so secured as to be easily removed, replaced, and repaired.

All steam and exhaust-pipes, the separator, and all steam-valves are to be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust-pipes in engine-room, and the separator, are to be also covered black walnut lagging with brass bands.

The steam-cylinders of all auxiliary engines are to be clothed and lagged the same as main cylinders.

After the boilers are in place and have been tested and painted they will be covered all over, except where directed, with asbestos quilting containing a layer of felt 1¼ inches thick, or with approved incombustible non-conducting material. This clothing will be covered on tops and sides, and on fronts where required, by galvanized wrought-iron plates, about No. 18 B. W. G., lapped not less than 1 inch and bolted together; also secured to boiler-plates in an approved manner.



WHISTLE.

A polished brass steam-whistle of approved pattern, with bell 5 inches in diameter, will be placed forward of the smoke-pipe, well above the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at or near the upper end. The pipe to have an expansion-joint at lower end.

RADIATORS.

Radiators or heating-coils, as may be directed, of approved patterns, will be furnished, fitted, and connected, with superficial areas, as follows:

In the cabin, two of 10 square feet each;

In the Commanding Officer's office, one of 2 square feet;

In the chart-room, one of 2 square feet;

In the Paymaster's office, one of 2 square feet;

In the ward-room, two of 20 square feet each;

In the steerage, two of 5 square feet each;

In the steerage-country, one of 20 square feet;

In the after compartment of berth-deck, one of 20 square feet;

In the middle compartment of berth-deck, one of 10 square feet;

In the forward compartment of berth-deck, one of 5 square feet;

Under the forecastle, such a number as may be directed, with total area of 50 square feet.

Each radiator or coil of more than 5 square feet surface is to be divided into two parts, and each of more than 10 square feet into three or more parts —each with its separate steam and drain-valve. The radiators in the crew's quarters will have the valve-stems squared and fitted with removable keys.

The steam and drain-pipes are to be of seamless-drawn brass of iron-pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union-joints to be coned, or to have corrugated copper washers. All holes through decks and bulkheads to be thimbled with brass. Steam and drain-pipes to be clothed where near wood-work. The steam-pipes will connect with the auxiliary steam-pipes where directed, and will be fitted with adjustable reducing-valves. The drain-pipe of each circuit will have an approved automatic steam-trap discharging into feed-tank, and elsewhere as directed.

SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing-boxes.

FLOOR-PLATES.

The engine-room, fire-room, uptake-room, and connecting passages are to be floored with wrought-iron plates $\frac{1}{4}$ inch thick, with neatly matched flat-topped corrugations running fore-and-aft. The plates are to be of convenient size and easily removable. They will rest on proper ledges, of angle or T-iron, and will have drain-holes where necessary. Platforms will be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods $\frac{5}{8}$ inch square, placed $\frac{3}{4}$ inch apart.

WORKING-PLATFORM.

The floors forward of the engine, on the starboard side, will be conveniently arranged to serve as a working-platform.

The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings are to be so placed near the working-platform as to be in full view while working the engines. Speaking-tube mouth-pieces and telegraph-levers are to be conveniently placed.

WORKING-LEVERS AND GEAR.

There will be at the working-platform the following hand-gear:

One reversing-lever;
Two cylinder drain-cock levers;
Two reversing-arm clamping-levers;
Engine stop-valve hand-wheel;
Bleeder-valve hand-wheel;
Receiver stop-valve hand-wheel;
Reversing-engine steam stop-valve hand-wheel.

All working-levers are to have spring catches of "locomotive pattern."

LABELS ON GEAR AND INSTRUMENTS.

All cocks are to have engraved brass plates to show their uses, and to indicate whether open or shut.

All valves, except such as may be directed, are to have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels.

All hand-levers will be similarly marked.

Gear for working valves from deck will be marked as above, or will have engraved brass deck-plates, as may be directed.

All main steam stop-valves are to have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph-dials, speaking-tube annunciators, and revolution-indicators will be suitably engraved to show to what they are connected.

All engraving is to be deep and filled in with black cement.

LADDERS.

Ladders will be fitted for reaching the engine-room from main and berth-decks, and the fire-room and uptake-room from the main-deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders

will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladders will be made with plate sides and double square-bar treads. All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches.

HAND-RAILS.

Finished brass hand-rails with finished wrought-iron stanchions, easily removable where required, will be fitted to all ladders and platforms and around all moving parts of machinery, and along bulkheads and passage-ways.

ENGINE-ROOM INSTRUMENTS.

The engine-room will be fitted with the following, in full view of the working-platform and properly lighted:

One Lane's improved spring steam-gauge connected to the main steam-pipe;

One Lane's improved spring compound-gauge connected to the receiver;

One spring vacuum-gauge connected to the main condenser;

One eight-day clock with second-hand;

One continuous rotary counter with positive motion, to register from 1 to 1,000,000;

One revolution-indicator, showing on a suitable dial the speed of the engines;

One telegraph-dial.

All the above gauges, clock, and counter are to have dials at least 8½ inches diameter.

There will also be the following instruments, attached directly to the various parts of the machinery in accessible positions:

One hot-well thermometer;

One feed-water thermometer on feed-tank;

One injection-water thermometer;

One discharge-water thermometer;

One steam-thermometer in main steam-pipe;

One mercurial vacuum-gauge on main condenser;

One counter or revolution-indicator on the circulating-pump;

One steam-gauge on auxiliary steam-pipe as before specified;

One steam-gauge, with 4½-inch dial, on low-pressure cylinder-jacket.

Each blowing-engine in fire-room will have an approved counter or revolution-indicator. Each feed-pump will have a spring-pressure gauge on its delivery side.

All instrument casings and fittings to be of polished brass. The thermometers are to be made permanent fixtures, with their stems and bulbs protected by brass covers.

LOG-DESK.

A desk of approved pattern, with locked drawer, is to be fitted in engine-room where directed.

INDICATOR FITTINGS AND MOTIONS.

An indicator connection is to be made to each end of each cylinder of main engines, as near as possible to the bore of the cylinder, and so as to be easily accessible. Each indicator when in place is to be connected to but one end of a cylinder. The connecting-pipes are to be 1-inch bore, without bends. The indicator-motion of each engine is to be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motions of the corresponding pistons. The steam-cylinders of all auxiliary engines are to have holes tapped for indicator fittings and then plugged. The engines are to have portable indicator motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated, but one set of indicator-motion fittings need be supplied for all engines of each kind.

ENGINE-ROOM TELEGRAPHS.

A repeating-telegraph of approved pattern is to be fitted in the engine-room and connected to four transmitters—one on poop, one on forecastle, the other two where directed. All transmitters are to be fitted with duplicate fixed locks and keys. The connections are to be made in such a manner that the chance of derangement shall be minimized.

SPEAKING-TUBES.

Speaking-tubes will be made of copper, not less than No. 20 B. W. G. They will connect the engine-room with the fire-room, the shaft-alley, the Chief Engineer's room, and two places on deck where directed; they will connect the fire-room with the upper deck close to ash-hoist, with the uptake-room, and with the berth-deck where directed.

Each tube will be fitted at each end with a mouth-piece and approved annunciator, the mouth-pieces to be connected to short flexible tubes where required. The tubes will be suitably cased where necessary.

REVOLUTION-INDICATORS.

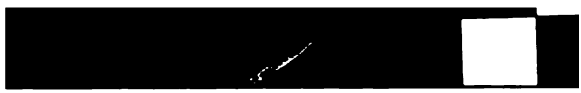
Revolution-indicators are to be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices.

TELL-TALES.

Tell-tales, with proper connections, are to be fitted in two places on deck, where directed, to show the direction of motion of the engines.

GOVERNOR.

An efficient governor of approved design is to be fitted and connected to the governor-throttle before specified. It must



be capable of quickly shutting the throttle from its wide-open position and of keeping it wide open when out of action.

LUBRICATION.

All working parts of machinery will be fitted with efficient lubricators with capacity for sufficient oil for four hours running. Each main crank-pin will have an automatic centrifugal oiling device, fed by a pipe from an oil-box on the adjacent engine-frames; also a telescopic or wiping oiling-gear as may be directed. All crank-shaft bearings will have oil-cups with wick-holders and tubes, so arranged that the oil passing down each tube to the journals can be seen and regulated. Wipers carried by the upper ends of the eccentric levers will furnish oil for lubricating the eccentrics, connections of the primary radius-bars with the eccentric levers and with the secondary radius-bars, and the connections of the valve-connecting-rods with the eccentric levers. These wipers will take oil from strips of webbing or other material as may be directed, carried by oil-cups suitably supported and capable of adjustment so as to feed oil in all positions of the valve gear. All moving parts, not above specified, will have approved automatic oiling-gear, which will furnish continuous lubrication. Each valve-chest is to have a globe or pump oil-cup directly over each steam-port and an approved oil-cup to lubricate each end of valve-stem. There will be fitted in the main steam-pipe, close to the high-pressure valve-chest, a Siebert, or equivalent, sight-feed oil-cup of one quart capacity. There will be smaller sight-feed cups on the circulating engines, fire and bilge-pump, main feed-pump, and blowing-engines; all sight-feed cups to have ample condensing surface on their steam-pipes. All the oiling of each auxiliary engine is to be done from one oil-box where practicable. All fixed oil-cups are to have hinged covers, with stops to prevent being thrown too far back. Moving oil-cups will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, will be of finished cast-brass, easily removable for cleaning.

OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-frames where possible, otherwise to be substantially made of sheet-brass. All drip-cups will have drain-pipes and cocks of at least ½ inch diameter which can be used while the engines are in operation.

ASH-SPRINKLERS.

There will be on athwartship bulkhead of fire-room, opposite each boiler, about 4 feet from floor, a brass nozzle with universal joint, with valve and sea connection for wetting ashes.

This to be of approved design, and to be secured alongside bulkhead when not in use.

A pipe will lead from the fire-room sea-suction to the uptake-room, and be fitted with a valve and short length of hose, with nozzle.

JOURNAL-BOXES.

All journals and moving parts of iron or steel are to run in composition boxes; the crank-pin and crank-shaft boxes to be lined with an approved anti-friction metal.

All bearings are to be adjustable for wear except as otherwise directed. All non-adjustable bushings to be of phosphor-bronze. All adjustable bearings to be provided with channeled brass chipping-pieces, securely held in place and easily removable.

STUFFING-BOXES.

All iron stuffing-boxes will be bushed with composition. All glands will be made of composition. Metallic packing will be fitted as before specified. All glands will be fitted with approved means of adjustment while the engines are in operation.

PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition. Air-chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

BOLTS AND NUTS.

All bolt-heads and nuts, except in special cases, are to conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, are to be kept from turning by dowels or other suitable devices. All bolts on moving parts and on pillow-blocks and stuffing-boxes, and elsewhere as directed, except where specified to be secured in other manner, are to be fitted with lock-nuts, and the bolts will extend beyond the nuts without threads; will be finished hemispherically, and fitted with split-pins.

GEAR FOR WORKING VALVES FROM DECK.

The rods for working the boiler stop-valves from the upper deck will be guided and supported by cast composition standards left rough and painted. Each rod will be squared on top, and will be fitted with a brass bar-handle which will be suitably stowed in beckets on the adjoining hatch-coaming. The tops of rods will be protected by brass caps.

SUPPORTS FOR LAMPS.

Supports for lamps will be fitted as and where directed.

LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turn-buckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

OIL-TANKS.

Two oil-tanks of 100 gallons capacity each, and one of 50 gallons capacity, will be fitted and well secured where directed, with facilities for filling from deck. They will be made of wrought-iron not less than $\frac{1}{8}$ inch thick, and will be internally stayed if required; each will have a man-hole and cover near the top, and a locked cock for drawing oil.

A copper oil-tank of 12 gallons capacity and one of 6 gallons will be fitted in engine-room, and one of 5 gallons in fire-room, all with lock-cocks.

All oil-tanks will be fitted with drip-pans.

An iron tallow-tank of 50 pounds capacity will be fitted where directed.

VENTILATORS.

Ventilators, with cowls well above the awnings, will be fitted—two to engine-room, two to fire-room, and two to uptake-room.

The engine-room ventilators will be 18 inches internal diameter; they will change to rectangular section at top of engine-room hatch, and will pass down inside the hatch at the forward end; air-ducts will lead from the bottoms to such parts of engine-room as may be directed.

The fire-room ventilators will be 24 inches internal diameter and will deliver air to the blowers.

The uptake-room ventilators will be 21 inches internal diameter; they will extend to within 3 feet of the uptake-room floors; they will have doors at the upper deck, and will be fitted with whips complete for hoisting ashes.

The ventilators will be made of wrought-iron, No. 11 B. W. G., butted and single-strapped, and flush-riveted. The cowls will be movable, made of copper, No. 12 B. W. G., not planished; they will be at least 33, 36, and 42 inches in greatest diameter, respectively. The base-rings of cowls will be of cast composition, finished on working parts, but left unfinished on the outside. All cowls will be fitted with an-

proved gear for turning them; the uptake-room and fire-room cowls being worked from deck by polished brass hand-wheels, and the engine-room cowls from the engine-room by similar hand-wheels, or by T-handles, as may be directed. The turning-gear to be of composition, with wrought-iron spindles. Each fire-room ventilator is to have an air-tight damper so arranged that it can be easily closed from fire-room in case its blower is stopped.

INSTRUMENTS AND TOOLS.

The following instruments and tools are to be furnished in addition to those elsewhere specified, viz:

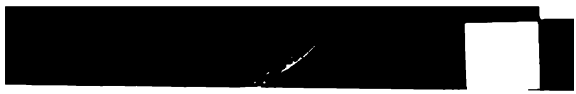
Five Thompson indicators of standard size, of the latest pattern made by the American Steam-Gauge Company: two for the high-pressure cylinder to have springs of 60 and 40 pounds to the inch; two for the low-pressure cylinder to have springs of 24 and 16 pounds; and one for auxiliary engines to have springs of 60, 40, and 20 pounds. All indicators to be nickel-plated, and to be complete with all attachments. Each indicator to be in its own case and to be suitably marked; cases to be conveniently stowed. Each indicator to have an extra cock attachment.

Two spare water-thermometers.

Two spare steam-thermometers.

One standardized thermometer in suitable case, with certificate of standardization.

One set of wrenches complete for engine-room and one for fire-room, to be fitted to all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch diameter will be finished, and for all over two inches diameter will be box-wrenches, where such can be used. Socket-wrenches to be furnished where required. Open-end wrenches are to be of steel or of wrought-iron, with case-hardened jaws; all others to be of wrought-iron or cast-steel.



One pair of taps, on rod, for tapping front and back tube-sheets of main boilers at one operation. This is to be a duplicate of that used in originally tapping the sheets, and is to be so packed as to be perfectly protected from injury.

Fixed trammels or gauges for lining up crank-shaft vertically and horizontally; marks for this purpose being made on brass plates let into the pillow-block frames.

Fixed trammels for setting the radius-link centers at their proper distances.

Fixed trammels for setting the main valves without removing covers; marks being made on the valve-stems for this purpose. All trammels to have protecting cases.

Two complete sets of fire-tools.

Six coal-buckets.

Four ash-buckets.

All instruments and tools to be properly stowed.

DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, are to be furnished, fitted, and ready for use, viz:

One set of valves for each pump;

One seat, with guards and bolts complete, for foot-valves, and one for delivery-valves of air-pumps;

One-half set of follower-bolts and nuts for each steam-piston, and one for air-pump piston;

One-half set of springs for each steam-piston;

One set of brasses for each crank-shaft journal;

One set of brasses for each crank-pin journal;

One set of brasses for each cross-head journal;

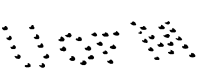
One composition shoe for each cross-head;

One set of brasses for thrust-bearing;

One complete set of brasses for each main engine valve-gear;

Six phosphor-bronze bushings for each non-adjustable joint of valve-gear;

One set of cup-leathers for each reversing-gear;



One complete set of brasses for each blowing-engine and one for circulating-pump engine;

A spare piston-rod for each pump-cylinder in fire-room;

A spare screw-propeller of such dimensions as may be required;

Two hundred condenser-tubes packed in boxes;

Fifty condenser-tube glands;

A spare hose and nozzle for steam-tube cleaner;

Ten stay-tubes, threaded to fit threads in tube-sheets, with ends wrapped in canvas;

Fifty ordinary boiler-tubes, swelled at one end and annealed ready for use. All boiler-tubes to be securely stowed in racks or as directed;

Ten stay-tube nuts;

One spare spring for each safety-valve and relief-valve;

One spare basket for each Macomb bilge-strainer;

One-eighth of a set of grate-bars and bearers.

All duplicate pieces not of brass are to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with the name painted on outside. Brass pieces are to be marked or stamped. All pieces to be stowed in an approved manner.

SECURING ENGINES IN VESSEL.

The engines will be adjusted and lined upon the engine-keelsons by means of hard wooden wedges driven from both sides of the bearing surfaces, and when accurately in line the spaces around holding-down bolts between sole-plates and keelsons will be filled by accurately fitting wrought-iron horseshoe washers, upon which the holding-down bolts will be set up and locked in place. When finally secured all shafting must be accurately in line, with the vessel at load-draught and ordinary stowage. The cylinder-axes must be parallel to each other, accurately in the plane of crank-shaft, perpendicular to the journals, and pointing to the centers of crank-pins. The con-

tractors for the hull will supply the labor to fit the seatings to the engines, boilers, and auxiliaries, and will stow hand-gear of windlass.

MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength, or to a marked degree its sightliness.

All nuts on rough castings are to fit facings raised above the surface. All flanges of castings are to be faced, and those coupled together are to have their edges made fair with each other. The facings of all circular flanges are to be grooved.

All bolt-holes in permanently fixed parts are to be reamed, or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All threads on bolts and nuts are to be of the United States Navy standard.

All pipes beneath floor-plates are to be connected by forged bolts and nuts of Tobin's metal.

All brasses are to fit loosely between collars of shafting.

All brasses or journals are to be properly channeled for the distribution of oil.

Packing for stuffing-boxes to be such as may be approved.

All small pins of working parts are to be well case-hardened.

All steel joint-pins of valve-gear are to be hardened and ground to true cylindrical surfaces.

All materials used in the construction of the machinery are to be of the best quality. The iron castings are to be made of the best pig-iron, not scrap.

Composition castings will be made of new materials. The various compositions will be by weight as follows, viz:

For all journal-boxes and guide-gibs, where not otherwise specified:

Copper, 6 parts;
Tin, 1 part;
Zinc, ½ part.

Tobin's metal:

Copper, 58.22 per cent.;
Tin, 2.30 per cent.;
Zinc, 39.48 per cent.

For composition not otherwise specified:

Copper, 88 per cent.;
Tin, 10 per cent.;
Zinc, 2 per cent.

Muntz metal to be of the best commercial quality.

Anti-friction metal to be of approved kind.

Ornamental brass fittings are to be of good uniform color.

All castings are to be increased in thickness around core-holes. Core-holes are to be tapped and the core-plugs screwed in and locked.

All steel forgings are to be without welds and to be free from laminations.

All flanges, collars, and off-sets to have well-rounded fillets.

All boiler-plates are to be well cleaned of oxide-of-iron scale.

All flanged parts of boilers are to be annealed, after flanging, in an approved manner.

India-rubber valves are to be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments are to be screwed through the boiler-plates, with heads inside.

All work is to be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

TESTS OF MATERIAL.

All materials used in the construction of the boilers, shafting, and steel castings, will be tested in accordance with the "Instructions to Inspectors," a copy of which is appended to these specifications.

All boiler and condenser-tubes must be tested to 300 pounds internal water-pressure before being put into place. India-rubber valves taken at random must stand a dry-heat test of 270° F. for one hour and a moist-heat test of 320° F. for three hours without the quality being impaired.

TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 150 pounds to the square inch above atmospheric pressure. This pressure is to be obtained by the application of heat to water within the boilers, the water filling the boilers quite full.

Each high-pressure cylinder, jacket, and valve-chest, the steam-pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler-pressure are to be tested by water-pressure to 150 pounds to the square inch, the low-pressure cylinders and connections to 75 pounds, and the condensers to 30 pounds. The pumps, valve-boxes, and air-vessels of the feed, fire, and bilge-pumps are to be tested to 200 pounds per square inch. The cylinders and condensers are to be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the test. All parts are also to be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests.

PAINTING.

After a satisfactory test the boilers are to be painted on the outside with two coats of brown zinc and oil.

All engine-work, not finished, to be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, is to be painted with two coats of white lead and oil, and the boiler fronts with two coats of lamp-black and oil.

The smoke-pipe is to be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipes, except the interiors of the cowls, which will be painted vermilion.

All steam-pipes not lagged with wood will be painted white; exhaust-pipes, green; water-supply pipes, red; and water-discharge pipes, lead-color.

PRELIMINARY TESTS AND TRIALS.

Steam is not to be raised in the boilers until after the water-test on board, unless desired for drying joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required, to test the connections and the workings of all parts of main and auxiliary engines. All expense of such preliminary tests will be borne by the contractor.

INSPECTOR'S OFFICE.

A suitable office and draughting-room, properly fitted and heated, is to be furnished by the contractor for the use of the Inspector of Machinery and his assistants during the building of the machinery and its erection on board.

RECORD OF WEIGHTS.

All materials and parts of machinery must be carefully weighed by the contractor when ready to go on board the vessel, and a record of the weights in detail furnished to the Inspector, certified to by him, and reported to the Bureau of Steam Engineering.

WORKING-DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by, and at the expense of, the contractor. Those which are merely developments of the drawings fur-

nished and of these specifications will be subject to the approval of the Engineer-in-Chief or of the Inspector of Machinery, as may be directed, before the work is ordered or commenced.

All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Inspector of Machinery, who will keep a record of the same, together with his decisions, and forward it to the Bureau of Steam Engineering.

CHANGES IN PLANS.

The contractor must make no changes from the drawings furnished except as herein directed, or from the provisions of these specifications, without preparing complete plans of such proposed changes and submitting the same to the Engineer-in-Chief for approval.

DRAWINGS OF COMPLETED MACHINERY.

A complete set of general and detail drawings of the machinery and boilers, as fitted, must be furnished by the contractor, certified to by the Inspector of Machinery, and forwarded to the Bureau of Steam Engineering immediately upon completion of the work.

OMISSIONS.

The engines, boilers, uptakes, and smoke-pipe, all auxiliaries, piping and connections, all sea-valves (except the cutting of the holes for the same), and all parts described in these specifications and in the official drawings are to be fitted complete to the vessel by the engine contractors, and any part of the machinery, or any article pertaining thereto, which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.

TESTS OF STEEL FOR CRUISERS.

INSTRUCTIONS TO INSPECTORS.

The following rules are prescribed in order to insure the fulfillment of the clause of the Act of Congress of August 5, 1882: "Such vessels * * * to be constructed of steel of domestic manufacture, having as near as may be a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum."

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays are to be inspected and tested at the place of manufacture by a Naval Inspector of Material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the ship-builders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle supplied for these vessels is to be clearly and indelibly stamped in two places, and with two separate brands: 1st. With that of the maker, which shall distinguish the name of the manufactory or company; 2d. With the regulation brand of the Naval Inspector of Material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed an inspection for surface or other defects of manufacture and the physical tests have been accepted by the Inspector and have been stamped with the maker's brand.

In case of small articles passed in bulk the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building yards for incorporation into vessels except it bear, either upon its surface or that of its packing, both of these brands as evidence that it has passed the necessary Government inspection.

III. The weight of all plates, beams, angles, &c., must be obtained by the Inspector of Material before delivery.

Plates of 12½ lbs. per square foot or less, and strips and bars of 6 lbs. per lineal foot or less, may be accepted if the weights vary between 3 per cent. above and 5 per cent. below the specified weights.

All other plates and shapes may be accepted if the weights vary between the specified weights and 5 per cent. below them.

All plates and shapes not being within the limits here specified may be rejected.

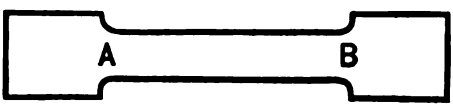
TESTS.

All material, except boiler-plates, should be tested by heats, as follows:

A specimen ingot or bloom shall be selected and rolled into a plate or bar and test pieces cut therefrom, provided always that the test pieces shall have received no more working than that which the finished material from the heat would receive.

Four test pieces, of the form shown in figure 1, for plates (square, or round, in condition as finished at the rolls, may be used for the tests of shapes), shall be made and tested for each heat.

Fig. 1.



The length A B must be at least 8 inches of uniform cross-section of which the area should not be less than $\frac{1}{4}$ nor more than $\frac{8}{10}$ of one square inch.

The reduction of width throughout the length A B must be just sufficient to prevent failure in the grips.

The test pieces must not be annealed unless the finished material is to be annealed.

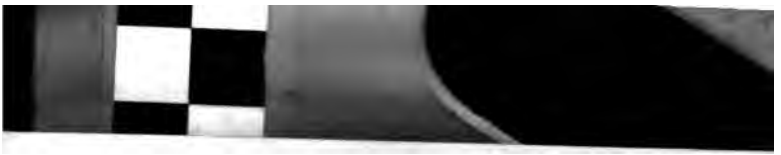
Each test piece shall be submitted to a direct tensile stress until it breaks, in a machine of approved character.

The initial stress to be 30,000 pounds per square inch.

The first load to be kept in continuous action for one minute.

An observation to be made of the corresponding elongation measured upon the original length of 8 inches.

The stress then to be increased slowly until the principal elastic limit is determined, after which additional loads will be added at intervals of time nearly as possible equal, and separated by half a minute; the loads to produce an increase of stress of 5,000 pounds per square inch of original section of the test piece until the stress is about 50,000 pounds per square inch of original section, when increments of stress *should not* exceed 1,000 pounds per square inch. Upon close



approach to the possible ultimate strength, the load to be increased gradually and its maximum value carefully noted.

The final elongation to be that obtained after rupture.

A list of all ingots made from each heat must be supplied to the Inspector. Each ingot must be stamped in his presence with the number of the heat. He must also see the test plate or billet cut off, stamped, and rolled, and place a private stamp upon it in such a way that each test piece will have the impression of the stamp near one end.

CONDITIONS OF ACCEPTANCE.

In order to be accepted, the average of the four test pieces must show an ultimate tensile strength of at least 60,000 pounds per square inch of original section, and a final elongation in 8 inches of not less than 25 per centum.

Material which shows a strength greater than 60,000 pounds per square inch will be accepted, provided the ductility remains at least 23 per centum.

CASES OF FAILURE.

If the average of these four test pieces, numbered 1, 2, 3, and 4 (called Test I), fall below either of the required limits, the ingot from which pieces 1, 2, 3, and 4 were cut shall be rejected, and Test II made, consisting of pieces 5 and 6, cut from a second ingot; if the mean of the results of these two fall below either of the above limits, the entire lot shall be rejected. If it be successful, Test III, or the mean of pieces 7 and 8, cut from a third ingot, shall decide.

If in any of the tests I, II, III, any single piece shows a tensile strength less than 58,000 pounds, or a final elongation less than 21 per cent., the ingot from which it was taken shall be rejected, and that test considered to have failed, regardless of its average.

QUENCHING TEST.

IV. A test piece shall be cut from each plate, angle, or beam, and, after heating to a cherry-red, plunged in water at a temperature of 82° Fahrenheit. Thus prepared, it must be possible to bend the pieces under a press or hammer so that they shall be doubled round a curve of which the diameter is not more than 1½ times the thickness of the plates tested, without presenting any trace of cracking.

These test pieces must not have their sheared sides rounded off, the only treatment permitted being the taking off the sharpness of the edges with a fine file.

Inspectors may require a cold-bending test when considered necessary.

ANGLES, BEAMS, BULB-BARS, T-BARS, ETC.

V. Angle-bars are to be subjected to the following additional tests: A piece cut from one bar in twenty to be opened out flat, while cold, under the hammer; a piece cut from another bar in the same lot shall be closed until the two sides touch, while cold.

Bulb and T-bars are to be submitted to a closing test similar to that prescribed for angle-bars.

Bars submitted to these tests must show neither cracks, clifts, nor flaws.

RIVETS.

Each 1,000 pounds of rivets from the same heat of metal shall constitute a lot, and be accompanied by two sample bars, each 18 inches long, for tensile test. These samples for tensile test shall be cut from the bars from which the lot of rivets is made, and be stamped with a number which shall also be placed on each box or package of that lot.

These samples to be subject to the same tensile test as that required for the plates.

The lot of rivets from which this sample bar does not fulfill the requirements of tensile strength and elongation required for plates is to be rejected.

From each lot, six rivets are to be taken at random and submitted to the following tests, two rivets to be used for each test:

1st. Two rivets to be flattened out cold under the hammer to a thickness of one-half the diameter without showing cracks or flaws.

2d. Two rivets to be flattened out hot under the hammer to a thickness one-third the diameter without showing cracks or flaws.

3d. Two rivets to be bent cold into the form of a hook with parallel sides without showing cracks or flaws.

BOILER MATERIAL.

Two tensile test pieces shall be cut from each plate rolled for boilers, and one quenching test piece, which shall be tested as before described, except that, in the tensile tests, the initial stress may be 25,000 pounds to the square inch.

The limits of strength for all plates, braces, stays, angles, and T-bars, shall be as follows:

The ductility in 8 inches must not be less than 25 per centum, and the ultimate tensile strength must not be less than 57,000 pounds and not more than 63,000 pounds; and no single piece must show a less

tensile strength than 57,000 pounds to the square inch, except plates for flanging and those used in the construction of the furnaces, which will have an ultimate tensile strength of not less than 50,000 and of not more than 55,000 pounds, and a ductility in 8 inches of not less than 29 per cent.

No steel for boilers which is to be worked at a heat or to be annealed after working in the boiler-shops, shall be annealed at the works.

The acceptance of material under these tests will not relieve the contractor from the necessity of making good any material which fails in working or may be rejected by the Inspector.

TESTS OF STEEL SHAFTS.

1. Each length of rough forged shaft must have a piece cut from it, at that end which was uppermost in the ingot, of sufficient size to allow the removal of specimens for tensile test, parallel with the axis of the shaft, having a measured length of 4 inches between reference marks and of ¼ square inch sectional area when finished.

2. From the piece so removed four test pieces shall be taken, two at circumference of finished diameter and two at ¼ radius from center. These pieces to be broken in a machine of approved character, under the same conditions as prescribed for "Tests of Steel for Cruisers."

3. The ultimate tensile strength of the four pieces must be within the limits of 26 and 30 tons (of 2,240 pounds) per square inch, and that of no single piece may fall below 25 tons. Pieces showing greater tensile strength than 30 tons will be accepted, provided the required ductility and other tests are satisfied. The ductility of no piece at outer radius may be less than 20 per cent., and that of no piece at inner radius less than 16 per cent., in the measured length of 4 inches.

4. Bars ¼ inch thick, cut at the outer radius, must stand bending double to an inner diameter of 1½ inches after common quenching in water from a low cherry-red temperature.

5. Pieces cut from the rough forged shaft for test may not be subjected to any subsequent treatment or process.

6. Inspectors of steel shafting shall have full facilities to assure themselves of the general good quality of the metal and of a satisfactory method of manufacture, and may reject any piece considered to be defective in quality or fabrication, without regard to the prescribed tests.

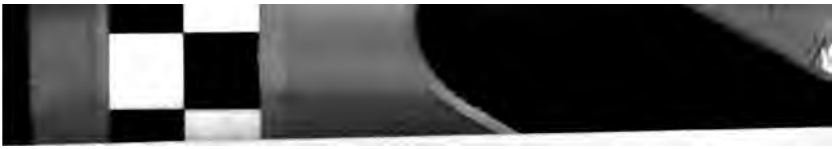
TEST OF STEEL CASTINGS.

All steel castings are to satisfy the following conditions:

Tensile strength to be between 60,000 and 70,000 pounds per square inch of cross section.

Extension in 8 inches of length to be at least 10 per cent.

Bars of the same metal 1 inch square should be capable of bending cold without fracture through an angle of 180° over a radius not greater than 1½ inches. Test pieces are to be taken from each important casting.



TEST OF STEEL CASTINGS.

All steel castings are to satisfy the following conditions :

Tensile strength to be between 60,000 and 70,000 pounds per square inch of cross-section.

Extension in 8 inches of length to be at least 10 per cent.

Bars of the same metal 1 inch square should be capable of bending cold without fracture through an angle of 90° over a radius not greater than 1¾ inches. Test pieces are to be taken from each important casting.